PROC. ENTOMOL. SOC. WASH.
85(4), 1983, pp. 698–703

ECHINOCOLEUS SETIGER HORN (COLEOPTERA: LEIODIDAE), AN INQUILINE IN THE NEST OF *POGONOMYRMEX* SPP. (HYMENOPTERA: FORMICIDAE)

WILLIAM P. MACKAY AND EMMA E. MACKAY

Departamento de Entomología, Colegio de Graduados, Escuela Superior de Agricultura "Hermanos Escobar" A.C., Cd. Juárez, Chihuahua, México; present address, Department of Biology, New Mexico State University, Las Cruces, New Mexico 88003.

Abstract.—Aspects of the biology of the myrmecophilous beetle *Echinocoleus setiger* Horn which occurs in the nests of the harvester ants *Pogonomyrmex montanus* MacKay and *P. subnitidus* Emery in southern California, USA, are discussed. There was a single generation per year with peak populations occurring in the nest in August.

Considerable variation existed in the numbers of beetles found in each ant nest. The beetles occurred together in groups in the lower regions of the nests and seasonally migrated to areas with the highest humidity. They are either synoeketes or symphiles, licking host secretions and cleaning the body surfaces of the ants.

The genus *Echinocoleus* presently contains three species, all of which are myrmecophiles (Peck, 1976). The genus occurs in the southwestern United States including California, Arizona, New Mexico, and Texas and probably occurs in northern México.

During an investigation of the nest phenologies of *Pogonomyrmex* spp. harvester ants (MacKay, 1981), *E. setiger* Horn was collected in the nests of *P. montanus* MacKay and *P. subnitidus* Emery. This report discusses aspects of the biology of *E. setiger* and its interaction with the ants.

MATERIALS AND METHODS

Study areas.—The ant nests were excavated in southern California: *P. subnitidus* in chaparral near the Vista Grande Ranger Station at 1500 m in the San Jacinto Mountains of Riverside Co., and *P. montanus* in a yellow pine forest at Big Pine Flat at 2100 m in the San Bernardino Mountains of San Bernardino Co.

The beetles.—Peck (1973) placed the genus *Echinocoleus* in the tribe Ptomaphagini and subtribe Ptomaphagina of the subfamily Catopinae. The beetles are small (1.9–2.8 mm total body length) with a turtle-like body form and with the elytra covered with long semierect golden hairs, all of which protect the beetles from the ants.

The ants.—The two ant species are very closely related. Both belong to the subfamily Myrmicinae, the tribe Myrmicini, the nominal subgenus *Pogonomyrmex* and the *occidentalis* species group (MacKay, 1980a). The nests were in soil within clearings in the two plant communities (MacKay, 1981).

Nest excavation.—The nests were excavated in ten-cm levels. The contents of

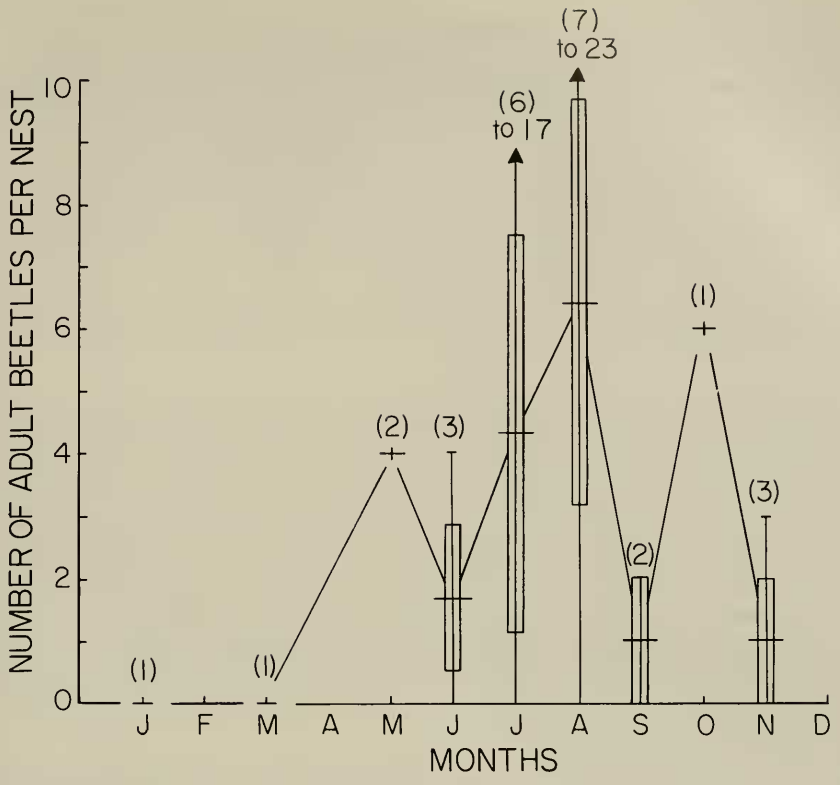

Fig. 1. Seasonal changes in mean numbers of *Echinocoleus setiger* in the nests of *Pogonomyrmex subnitidus*. Rectangles are ± one standard error, vertical lines are the ranges. The numbers of nests excavated are indicated by the numbers in parentheses.

the burrows, including dirt and animals, were placed in plastic containers and later the animals were separated from the dirt by hand. The beetles were preserved in 70% ethanol or were placed in plastic containers for later observations of their behavior. Complete excavation of a *P. montanus* nest required 6–10 hours and of a *P. subnitidus* nest, 20–30 hours.

Observations of living animals.—Ants were placed in observation nests ("Uncle Milton Ant Farms"©) which consisted of about 1 cm width of dirt sandwiched between pieces of clear plastic. The ants were allowed 24 hours to construct a burrow system, and then the beetles were added to the artificial nest.

Results and Discussion

Seasonal changes in the density of the beetle populations.—The adult beetles are most common in the nests of the two species of ants from mid summer to late fall (Fig. 1, Table 1). No beetles were found in the nests of *P. subnitidus* until May when four beetles were observed in each of two nests excavated (Fig. 1). There was a general increase in the beetle population until August. Apparently, at least *E. setiger* is not more common in the cooler months when the ants are less active, as was suggested by Peck (1976). The summer is not a pleasant time to excavate *Pogonomyrmex* spp. nests as the ants are most active and aggressive, but it is the time when the adult beetles are most common.

Table 1. Levels and numbers of *Echinocoleus setiger* collected from five nests of *Pogonomyrmex montanus* at Big Pine Flat, San Bernardino Mountains, San Bernardino County, California.

Nest number	Date of excavation	Level (cm)	Number of beetles
1	17-X-77	not recorded	5
2	12-VII-78	not recorded	3
3	30-IX-78	50	4
4	30-IX-78	not recorded	1
5	19-VIII-80	30	1
	19-VIII-80	50	1
	19-VIII-80	80	2

Considerable variation was observed in the numbers of beetles captured (Fig. 1). For example, during August we found nests without beetles and one nest with 23 beetles. We have no explanation for this variation. All nests were in the same area. There were no significant correlations between the numbers of beetles and numbers of adult ants ($r = 0.02$ ns), of larvae ($r = 0.54$ ns), or of pupae ($r = 0.48$ ns) for the 13 nests excavated in July and August. We excavated a total of 80 *P. montanus* nests, but found beetles in only five (Table 1), all located at Big Pine Flat. The other nests were located about 4 km east of Big Pine Flat. The vegetation and soil appeared similar throughout the area. We cannot explain the absence of *E. setiger* in the nests excavated in other areas. There was a mean of 3.4 beetles per *P. montanus* nest (Table 1).

Echinocoleus chihuahuensis Peck is univoltine (Peck, 1976). Eggs are deposited in the spring, mature larvae are present by early September, and the beetles pass the winter as adults. The seasonal cycle may be similar in *E. sonorensis* Peck (Peck, 1976), as larvae were found in April. Apparently *E. setiger* is also univoltine (Fig. 1). The adults appear in May, reach peak populations in August, with fewer adults occurring in late fall and winter. Although we collected all of the ant brood for determination of annual production, we found no beetle larvae with the ant larvae as was reported with *E. chihuahuensis* (Peck, 1976), or elsewhere in the nest.

Seasonal changes of the depths of the beetles in the nests.—The mean of the maximum nest depths is 67 cm for *P. montanus* and 230 cm for *P. subnitidus* (MacKay, 1981). Most beetles were found in the lowest regions of the nests of *P. montanus* (Table 1) and in the mid to lowest levels in the nests of *P. subnitidus* (Fig. 2).

Small standard errors suggest that the beetles have clumped distributions within the nests. The distributions of the beetles in July and August differ significantly from a Poisson distribution (chi-square = 10297.7, df = 253, $P < 0.001$), verifying a non-random distribution. The ratio of $s^2/\bar{x}$ is 2.0, demonstrating that the beetles have a clumped distribution within the nests.

The beetles tend to move from the 100–150 cm levels in the spring to near the 200 cm level in August and to the upper levels in the fall (Fig. 2). There are few differences among the levels below 20 cm in the seasonal changes in temperature (MacKay, 1981), but there are considerable differences among the levels with respect to the percent free water in the soil (MacKay, 1981). Until mid-May there

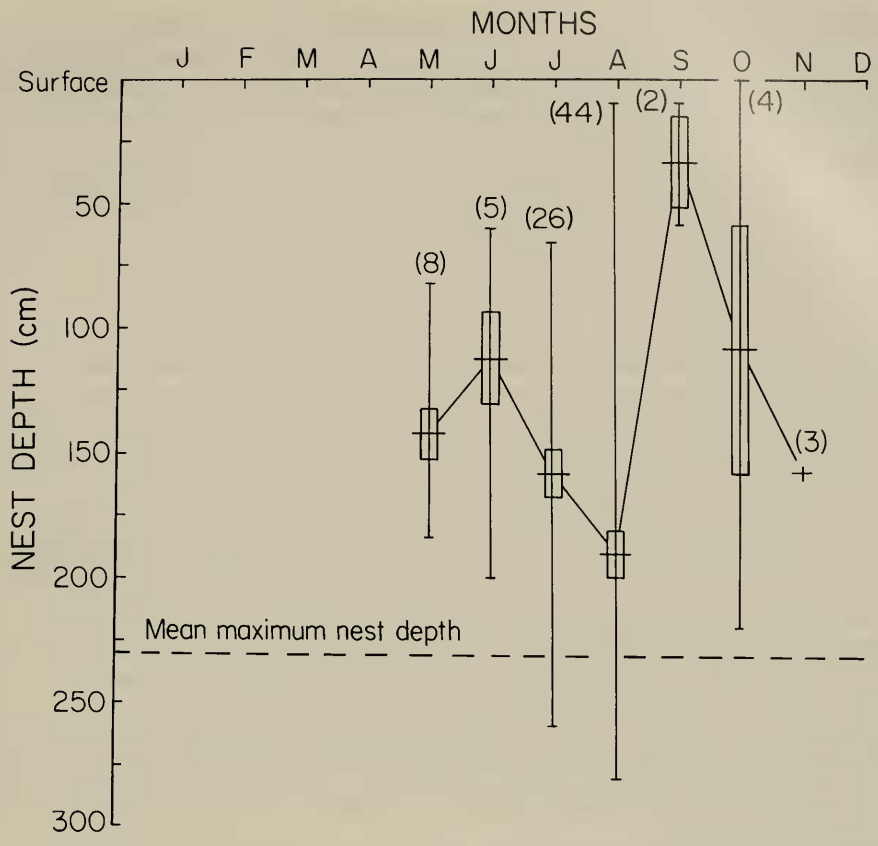

Fig. 2. Seasonal changes in depths of *Echinocoleus setiger* in nests of *Pogonomyrmex subnitidus*. The rectangles are ± one standard error, vertical lines represent the ranges. Numbers captured during each month are indicated in parentheses. The mean of the maximum nest depths is indicated as a dashed line.

was approximately 10% free water in all levels. Later in the summer the superficial levels became very dry (less than 2% free water). In the fall, rains again increased the water content of the soil to 5 or 10% free water. Beetles in the laboratory were kept in a very humid environment. Exposure of only a few hours without free moisture resulted in heavy mortality. The beetles apparently migrated to the nest areas with highest humidity. Similarly Peck (1976) reported that individuals of *E. sonorensis* were found in the upper half meter of a *P. rugosus* nest in April. In October, larvae of *E. chihuahuensis* were found only at depths of over one half meter (2 feet) together with the ant brood (Peck, 1976).

Relationship with the ants.—The beetles appear to be either synoeketes as suggested by Peck (1976) or symphiles. They rapidly scurry away when approached by a worker, winged male, or winged female. Adult ants and winged females often attack the beetles. The ants must be very close to the beetles or actually touch them with their antennae in order to detect their presence. The beetles quickly escape by burrowing into the soil. The ants continue to pursue the beetles, digging

Table 2. The presently known ant hosts and distributions of the three species of *Echinocoleus*.

Species	Host	Distribution
E. chihuahuensis Peck	*Pogonomyrmex maricopa* Wheeler	Texas, New Mexico
E. setiger Horn	*Aphaenogaster albisetosa* Mayr	Arizona
	Pogonomyrmex montanus MacKay	Southern California
	P. subnitidus Emery	Southern California
E. sonorensis Peck	*P. rugosus* Emery	Arizona

after them and attempting to capture them using the mandibles and front legs. The beetles usually manage to escape. The limuloid body shape and the stiff hairs on the dorsum protect them from the ants. When the ants do close their mandibles on a beetle, it snaps away from the ant. We saw numerous aggressive encounters, but never saw an ant kill a beetle.

Most of the time the beetles are either buried in the bottom of a burrow at depths less than a half cm or are scurrying around in the nest. Occasionally a beetle encounters an ant which becomes very docile. The beetle climbs a posterior leg and begins licking the ant's dorsal surface. The ant lowers its antennae and patiently allows the beetle to move over its surface. When the beetle moves onto the ant's head, the ant usually attempts to dislodge it with the anterior legs. The beetle moves to the middle of the head, above and between the eyes, where the ant's anterior legs cannot reach. In these encounters, the ant displays no aggressive behavior toward the beetle. If the ant moves, the beetle moves to the dorsal surface of the ant's gaster. We frequently saw beetles in the observation nest riding on the gasters of ants.

Peck (1976) suggested that the beetles scavenge waste materials in the nests, as catopines are generally scavengers. However, dead ants in the observation nest were never approached by *E. setiger*. Apparently their habits are similar to the common ant crickets, *Myrmecophila* spp. which lick host secretions and clean the body surfaces of the ants.

Evolution and host relations of the genus.—The genus probably evolved from a New World *Ptomaphagus* (*Adelops*) ancestor (Peck, 1976). Several *Ptomaphagus* (*Adelops*) spp. are found in ant nests (MacKay, 1980b). A species in the *consobrinus* group may have invaded *Pogonomyrmex* ants nests in the developing Pliocene Sonoran desert (Peck, 1976), and later differentiated into an *Echinocoleus* sp. which became separated by a woodland-grassland range into eastern and western populations during a Pleistocene glacial period. The western population may have differentiated to become *E. setiger*. *Pogonomyrmex* spp. are the most common hosts of the three known species of *Echinocoleus* (Table 2), but *E. setiger* also occurs in nests of *Aphaenogaster albisetosa* Mayr (Table 2). We excavated 20 *P. rugosus* Emery nests near Riverside, California, and although we captured numerous myrmecophiles, we captured no *Echinocoleus* sp.

There are undoubtedly undescribed species which occur in the nests of other *Pogonomyrmex* spp. and more host records to be obtained for the presently known species. Unfortunately, collection of these beetles is difficult because of the aggressive nature and painful stings of the ants.

Acknowledgments

We thank James Zimmerman and Gregory Forbes for critical reviews of the manuscript and Stewart Peck for identification of the beetles. The beetles were deposited in the collection of Stewart Peck. María Concepción García Medina and Alma Rosa Salas Portillo carefully typed the manuscript. The preparation and publication of the manuscript was supported by the Department of Entomology of the Graduate School, Escuela Superior de Agricultura.

Literature Cited

MacKay, W. P. 1980a. A new harvester ant from the mountains of southern California (Hymenoptera: Formicidae). Southwest. Nat. 25: 151–156.

———. 1980b. *Ptomophagus californicus* (LeConte) (Coleoptera: Leiodidae), an inquiline in the nests of the ant *Formica haemorrhoidalis* Emery. Coleopt. Bull. 34: 79–83.

———. 1981. A comparison of the nest phenologies of three species of *Pogonomyrmex* harvester ants (Hymenoptera: Formicidae). Psyche (Camb., Mass.) 88: 25–74.

Peck, S. 1973. A systematic review and the evolutionary biology of the *Ptomaphagus* (*Adelops*) beetles of North America (Coleoptera, Leiodidae; Catopinae), with emphasis on cave-inhabiting species. Bull. Mus. Comp. Zool., Harvard Univ. 145: 29–162.

———. 1976. The myrmecophilous beetle genus *Echinocoleus* in the southwestern United States (Leiodidae; Catopinae). Psyche (Camb., Mass.) 83: 51–62.